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ScienceDirect

Behavior Therapy 45 (2014) 806–816

Behavior Therapy

www.elsevier.com/locate/bt

Associations Between Sleep Hygiene and Insomnia Severity in College Students: Cross-Sectional and Prospective Analyses

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Although a small number of studies characterized cross-sectional associations between sleep hygiene and insomnia severity, no prior study has examined their relationships prospectively. Further, the relationship between sleep hygiene and insomnia severity among college students has rarely been examined. This study examined the prevalence of diverse sleep hygiene behaviors and their associations with insomnia severity in two independent samples of college students from a cross-sectional (N = 548; mean age = 19; 59% female; 71% White) and a two-wave short-term prospective (N = 157; mean age = 19; 71% female; 76% White) study. A total of 12% to 13% of students reported clinically significant insomnia. On average, students reported frequent engagement in inconsistent sleep-wake schedules and lounging and worrying/thinking about important matters in the bed. Improper sleep scheduling, behaviors that promote arousal near bedtime, and uncomfortable sleeping environments were positively associated with cross-sectional insomnia severity. After controlling for other well-established risk factors, only improper sleep scheduling remained significant. Prospectively, baseline improper sleep scheduling predicted insomnia severity at a 2-month follow-up after controlling for baseline insomnia severity and other well-established risk factors. Together, findings suggest a potential unique role of improper sleep scheduling in insomnia among college students.

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0005-7894/45/806-816/$1.00/0

Keywords: insomnia; sleep hygiene; college health; prospective study

INSOMNIA, CHARACTERIZED BY DIFFICULTIES in initiating or maintaining sleep at least 3 nights per week for at least 3 months, leading to significant impairment (American Psychiatric Association, 2013), has been shown to be highly prevalent and associated with serious negative consequences in college students. It has been estimated that 40% to 77% of students suffer from poor sleep quality, a broad measure of general sleep difficulties, such as frequent awakenings, difficulties initiating sleep, nonrestful sleep, and low total sleep time (Buboltz, Brown, & Soper, 2001; Lund, Reider, Whiting, & Prichard, 2010; Vail-Smith, Felts, & Becker, 2009). Also, approximately 10% of college students met DSM-5 diagnostic criteria (American Psychiatric Association, 2013) for insomnia (Taylor, Bramoweth, Grieser, Tatum, & Roane, 2013). Poor sleep quality has been positively correlated with a variety of problematic and risky behaviors, including fighting, risky sexual activity (Vail-Smith et al., 2009), suicidal ideation (Nadorff, Nazem, & Fiske, 2011), and motor vehicle accidents (Taylor & Bramoweth, 2010) in college students. In addition, sleep length and sleep quality have been shown to be negatively correlated with grade point average (Gaultney, 2010; Kelly, Kelly, & Clanton, 2001). Furthermore, once it develops, insomnia is shown to

be likely to persist (Morin et al., 2009) and to be a risk factor for serious problems in the general population, such as a compromised immune system (Cohen, Doyle, Alper, Janicki-Deverts and Turner, 2009; Savard, Laroche, Simard, Ivers, & Morin, 2003), depression (Baglioni et al., 2011), and early mortality (when combined with short sleep duration; Vgontzas et al., 2010). Because of the high prevalence of insomnia and its potential grave short-term and long-term negative consequences, it is critical to identify risk factors for insomnia among college students.

Diverse lifestyle behaviors and environmental conditions have been associated with insomnia, and the collection of these behaviors is termed *sleep hygiene* (SH; American Academy of Sleep Medicine, 2005). According to the *International Classification of Sleep Disorders* (ICSD-2; American Academy of Sleep Medicine), SH behaviors are classified into five categories: improper sleep scheduling (e.g., napping, inconsistent bed and wake times); the use of sleep-disrupting products (e.g., caffeine, cigarettes); behaviors that promote arousal near bedtime (e.g., planning, engaging in exciting or emotionally upsetting activities); engagement in behaviors in the bedroom other than sleep (e.g., television watching, reading); and failure to maintain a comfortable sleeping environment (e.g., uncomfortable mattress or temperature).

Experimental investigations have shown that a number of SH behaviors listed above disturb sleep (for a review, see Stepanski & Wyatt, 2003), yet treatment and survey studies have led researchers to question the importance of SH as a causal factor of insomnia in the general population. For example, clinical studies do not support SH education as a stand-alone intervention to be efficacious for individuals with insomnia (Morgenthaler et al., 2006). Also, the majority of poor SH behaviors were low in frequency among both good and poor sleepers (Gellis & Lichstein, 2009). Cross-sectional studies to identify specific SH behaviors associated with concurrent insomnia have revealed mixed results. For example, Cheek, Shaver, and Lentz (2004) found that middle-aged women with poor sleep were in fact more likely to adhere to desirable SH behaviors including refraining from caffeine intake, alcohol use, and bedtime variability, compared to women with good sleep. Harvey (2000) found no differences between adults with and without sleep onset insomnia on a variety of SH behaviors. McCrae and colleagues (2006) found that, out of many SH behaviors examined, the frequency of napping was the only SH behavior that was greater among those complaining of insomnia symptoms in older adults. Jefferson and colleagues (2005) found greater frequencies of napping, drinking, and smoking in those with insomnia among a random sample of adults. However, Gellis and Lichstein found no differences in substance use between good and poor sleepers in a national Internet-based sample; yet poor sleepers were more likely to report an uncomfortable sleeping environment and behaviors that promote arousal at bedtime. These studies overall seem to suggest that SH may not be a primary factor causing current insomnia or poor sleep among adults in the general population. However, not all of these cross-sectional studies measured all SH categories, which makes it difficult to draw conclusions regarding the importance of specific SH categories. Further, the variable definitions of poor sleep and insomnia, in addition to differences in sex and age of samples examined, make it difficult to compare across studies.

As compared to adults in the general population, SH may be more problematic in college students. The newfound independence of being in college may lead students to engage in inconsistent sleep schedules and to use substances that may impair sleep (e.g., alcohol, caffeine, cigarettes, other stimulants). Poor SH behaviors may occur because college students prioritize social and school activities at the expense of good SH or because they lack knowledge about the importance of good SH. College students, particularly those living in dormitories, also tend to be afforded less living space than community-living adults, which may lead them to engage in behaviors in the bedroom other than sleep (e.g., television watching, reading). Finally, college students living with roommates and/or housemates in dormitories, fraternity/sorority houses, or crowded apartments tend to have less control over living conditions (e.g., loud noises, lack of control over temperature) and to be more susceptible to uncomfortable sleeping environmental conditions.

A few cross-sectional studies found potential roles of poor SH in college students' poor sleep quality. A broad index of SH behaviors was significantly worse among college students with poor sleep quality, as compared to good sleepers (Brown, Buboltz, & Soper, 2002; Suen, Tam, & Hon, 2010). Among specific categories of SH behaviors, inconsistent sleep schedules were found to be prominent in those with poor sleep quality among colleges students (Lund et al., 2010), whereas differences in drinking frequency between good and poor sleepers have been mixed in this population (Kenney, LaBrie, Hummer, & Pham, 2012; Taylor et al., 2013).

To date, no study has documented the prevalence of the complete range of individual SH behaviors as defined by the American Academy of Sleep Medicine (2005) among U.S. college students. Examination of individual SH behaviors is important to identify the specific SH behaviors that are prevalent and associated with insomnia in a specific population, which in turn may inform intervention strategies tailored to

the given population. However, prior studies either used an aggregated score of all SH items (Brown et al., 2002; Suen et al., 2010) or examined only a subset of specific SH behaviors (Kenney et al., 2012; Taylor et al., 2013) and thus could not compare the prevalence and importance of diverse SH behaviors. Furthermore, no study has assessed the prospective association between a complete range of SH behaviors and insomnia severity in the general population and college students. A prospective analysis is important, because it allows us to examine correlates of subsequent insomnia severity after accounting for prior insomnia severity.

This paper presents results of two studies. The first study (Study 1) examined the frequency of a full range of SH behaviors and their cross-sectional relationships with insomnia severity in a large sample of college students. In the second study (Study 2), using a short-term prospective study design, we examined whether poor SH predicted insomnia severity at a 2-month follow-up, after controlling for the baseline insomnia severity. Recent studies have identified various risk factors for poor sleep among college students, including anxiety, depression, preferences to be awake during the evening, and female gender (Lund et al., 2010; Taylor et al., 2013). Thus, we assessed the association between SH and concurrent and prospective insomnia severity, with and without controlling for these well-established risk factors for insomnia. It was hypothesized that college students would report frequent poor SH behaviors. We did not have a prior hypothesis regarding specific SH categories associated with insomnia cross-sectionally and prospectively, given scarce and mixed prior findings.

Method

PARTICIPANTS AND PROCEDURES

All participants were recruited from undergraduate students enrolled in the introductory psychology course at a private university in the northeastern United States. Online surveys were completed by the participants at a time and place of their own choosing and they received partial course credit for completing the study. Participants were required to be 18 years or older to enroll. Electronic informed consent was obtained from each participant and all study measures and procedures were reviewed and approved by the university's Institutional Review Board.

Study 1

Enrollment occurred during the 2009 fall semester. A total of 613 students completed the questionnaire; however, for the current analyses, data from 548 participants were used, after excluding 65 students (11%) with missing data. This sample was on average 18.79 years old (SD = 1.37; range = 18 – 38) and was 59% female. The sample consisted of 71% White, 13% Asian, 7% Black, 1% Native American, and 8% multi-racial or other race, and 6% Hispanic or Latino. Independent-sample t-tests for continuous variables and χ^2 tests for categorical variables were conducted to compare participants who were excluded from the study due to missing data (n = 65) with those retained (n = 548). There was no significant difference in all study variables including demographics at $p < .10$, with the exception that those excluded (M = 10.75; SD = 5.35) reported a significantly higher insomnia severity than those retained (M = 8.67; SD = 4.88), $t(605) = 3.07$, $p = .002$, (Cohen's $d = .41$), which reflects a small to moderate difference between groups.

Study 2

Data were taken from a larger longitudinal study on alcohol use in college students. In addition to being at least 18 years of age, participants were also required to have had at least one alcoholic drink in the previous 30 days. Participants completed two online surveys with an average interval of 68 days (SD = 10.22) between assessments at Time 1 (September 8 to October 1, 2012) and Time 2 (November 24 to December 5, 2012). Of the 172 students who participated in the Time 1 survey, 157 students (91%) also participated in the Time 2 survey. For the current analyses, data from 157 participants who completed both surveys were used (i.e., completers), after excluding 15 participants who did not complete the Time 2 survey (i.e., attriters). This sample of 157 participants was on average 18.87 years old (SD = 1.11, range = 18 – 23) and 71% female. The sample consisted of 76% White, 11% Asian, 6% Black, 1% American Indian, and 6% multi-racial, and 6% Hispanic or Latino. Independent-sample t-tests for continuous variables and χ^2 tests for categorical variables were conducted to compare our final sample (n = 157) to attriters (n = 15). Results showed two significant differences out of all Time 1 study variables including demographics at $p < .10$. Attriters (43%) were significantly less likely to be White compared to the final sample (76%), $\chi^2 = 7.47$, df = 1, $p = .01$; attriters (M = 12.73; SD = 5.57) also reported higher insomnia severity at Time 1 compared to the final sample (M = 8.66; SD = 5.36), $t(170) = 2.80$, $p = .006$ (Cohen's $d = .74$), which reflects a medium difference between groups.

MEASURES

Insomnia Severity

The Insomnia Severity Index (ISI; Bastien, Vallieres, & Morin, 2001) was used to assess insomnia severity experienced during the previous 2 weeks in Study 1

and Study 2, Time 2. The measure includes 7 items; each item is assessed on a scale ranging from 0 (*not at all*) to 4 (*very much*). A total score ranges from 0 to 28, and higher scores indicate greater insomnia severity. The ISI has been shown to be a reliable and valid measure of subjective insomnia severity (Bastien et al., 2001; Gellis & Park, 2013). Total scores greater than 14 have been suggested as the cutoff for clinical insomnia, and scores between 8 and 14 have been suggested as the range for subclinical insomnia (Buysse et al., 2006). A total score was used for current analyses.

Sleep Hygiene (SH)

The Sleep Behaviors Questionnaire (Gellis & Lichstein, 2009) was used to assess SH in Study 1 and Study 2, Time 1. The Sleep Behaviors Questionnaire is a 19-item measure based on The International Classification of Sleep Disorders (ICSD)-II criteria for *inadequate sleep hygiene*. The Sleep Behaviors Questionnaire lists a variety of activities that are characteristic of unhealthy sleep-related behaviors. Participants indicated the average number of days per week, ranging from 0 to 7, in which they engaged in these poor SH behaviors during the previous month. There are five thematically related subscales, which correspond to the categories for the ICSD diagnosis of inadequate sleep hygiene: the 3-item Improper Sleep Scheduling Subscale, the 4-item Use of Sleep-Disrupting Products Subscale, the 4-item Arousing Behaviors Near Bedtime Subscale, the 4-item Use of the Bed for Activities Other Than Sleep Subscale, and the 4-item Uncomfortable Sleeping Environment Subscale. Note that, in Study 1, the item related to alcohol use was dropped to avoid questions related to potential illegal activities in underage students; thus, the Sleep-Disrupting Products Subscale score was calculated with 3 items. Scale scores of the five SH subscales were used for the current analyses.

Depression

The Patient Health Questionnaire-9 (PHQ-9), a reliable and valid 9-item measure of depression (Kroenke, Spitzer, & Williams, 2001), was used to assess depression severity in Study 1. Participants reported how often they experienced each of the nine symptoms for a major depressive episode during the previous 2 weeks, based on a scale ranging from 0 (*not at all*) to 3 (*nearly every day*). For the current analyses, a total score of 8 items (potentially ranging from 0 to 24) was used after dropping 1 item that assessed insomnia or hypersomnia. In Study 2, the Patient Health Questionnaire-2 (PHQ-2), a reliable and valid 2-item measure of depression (Kroenke, Spitzer, Williams, Monahan, & Lowe, 2007; Lowe et al., 2010), was used. This measure includes the first two questions of the PHQ-9, and a total score ranges from 0 to 6, with higher scores indicating higher depression.

Anxiety

The Generalized Anxiety Disorder 7-item scale (GAD-7), a reliable and valid 7- item measure of generalized anxiety (Spitzer, Kroenke, Williams, & Lowe, 2006), was used in Study 1. Participants reported how often they were bothered by 7 symptoms of anxiety over the previous 2 weeks on a scale ranging from 0 (*not at all*) to 3 (*nearly every day*). The total score on this measure potentially ranged from 0 to 21. The Generalized Anxiety Disorder 2-item scale (GAD-2), a reliable and valid 2-item measure of generalized anxiety (Kroenke et al., 2007; Lowe et al., 2010) was used in Study 2. This measure includes the first two questions of the GAD-7, and a total score ranged from 0 to 6, with higher scores indicating higher anxiety levels.

Morning/Evening Preference

The Horne-Ostberg Morning/Eveningness Questionnaire (MEQ: Horne & Ostberg, 1976) was used in Study 2, Time 1, to assess an endogenous characteristic relating to a person's preference for wakefulness during the morning or evening hours. Participants responded to 19 items based on varied response scales. A total score potentially ranges from 16 to 86, and higher scores correspond to greater degrees of morning preference. The MEQ is a widely used measure for assessing morning/evening preference and it has been shown to discriminate between types among young adults (Horne & Ostberg).

DATA ANALYSIS STRATEGIES

Statistical analyses were performed using SPSS, Version 19. We used two-tailed testing with an alpha level of .05 to determine statistical significance. First, means (and standard deviations) of all study variables were obtained. Second, bivariate correlations coefficients of each individual SH behavior and five SH subscale scores with insomnia severity were obtained. Then, three sets of multiple linear regression analyses were conducted to examine the relationships of the five SH subscale scores with insomnia severity cross-sectionally and prospectively. The first model was to examine cross-sectional relationships between the SH subscale scores and insomnia severity without controlling for any covariates, using data from Study 1. The second model was to examine cross-sectional relationships between the SH subscale scores and insomnia severity, after controlling for covariates, again using data from Study 1. The third model was to examine prospective relationships between the SH subscale scores at Time 1 and insomnia severity at Time 2, after controlling for covariates and insomnia severity at Time 1, using data from Study 2. For this

longitudinal analysis, we used the covariance approach (predicting Time 2 insomnia severity controlling for Time 1 insomnia severity). We did not use the change-score approach (predicting the change score, which is calculated by subtracting Time 1 insomnia severity from Time 2 insomnia severity) for two reasons. First, our goal for this longitudinal analysis was to test whether prior SH would predict subsequent insomnia severity even after controlling for important risk factors including prior insomnia severity (which is conceptually in line with the covariance approach). Second, the change-score approach has been shown to result in inflated error and reduced statistical power (Cattell, 1983; Vickers & Altman, 2001), and our sample size for a longitudinal analysis was relatively small. No significance values of SH scores were altered in the two approaches after controlling for covariates and Time 1 insomnia severity. In all models, predictors were entered simultaneously to examine the unique effect of each predictor after accounting for the other predictors in the model. R^2 was calculated as an overall effect size measure for all the predictors in the model; a semi-partial correlation (sr^2) for each predictor was calculated as an effect size measure for each predictor.

Results

DESCRIPTIVE ANALYSES

As shown in Table 1, on average, both samples of college students showed subclinical levels of insomnia severity (Study 1 M = 8.67 [SD = 4.88]; Study 2 Time 1 M = 8.66 [SD = 5.36]; Study 2 Time 2 M = 7.50 [SD = 5.39]). A paired sample t-test showed that students from Study 2 reported on average lower insomnia severity at Time 2 than at Time 1, $t(156) = 2.88$, $p = .005$, indicating a small decrease in insomnia severity over time (Cohen's $d = .22$). In Study 1, 12% (n = 64) of students met criteria for clinical insomnia, 45% (n = 246) met criteria for subclinical insomnia, and 43% (n = 238) reported no insomnia. Table 2 shows insomnia categorizations at Time 1 and Time 2 in Study 2. Sixty percent of the Study 2 sample (n = 94) remained in a same insomnia category, 26% (n = 41) changed to a better category, and 14% (n = 22) changed to a worse category from Time 1 to Time 2.

All SH items and scale scores and their bivariate correlations with insomnia severity are shown in Table 1. In terms of specific SH behaviors, students showed relatively high frequencies (i.e., average frequency > 3 days per week in both studies) of inconsistent wake-up times and bedtimes, worrying/thinking about important matters at bedtime and in bed, and lounging in the bed. Five SH items showed significant and positive correlations with insomnia severity in both studies, including inconsistent wake-up times and bedtimes, lounging around in the bed, worrying/thinking about important matters in bed, an uncomfortable mattress, and a too-bright bedroom. In terms of SH scale scores, all the five SH scale scores showed significant and positive correlations with insomnia severity cross-sectionally. Prospectively, improper sleep scheduling (r = .28, $p < .001$), uncomfortable sleeping environment (r = .18, $p < .05$), and the use of the bed for activities other than sleep (r = .17, $p < .05$) subscale scores measured at Time 1 were significantly associated with insomnia severity measured at Time 2.

REGRESSION ANALYSES

For Study 1, two multiple linear regression analyses were conducted to examine the cross-sectional associations between SH subscale scores and insomnia severity without and with controlling for well-established covariates of insomnia. Table 3 shows the results of the first regression without controlling for covariates, including standardized coefficients (β), unstandardized coefficients (b), and semi-partial correlations (sr^2) for each SH subscale score. All predictors in this model together explained a significant and moderate-to-large portion of the variance in insomnia severity (R^2 = .19, $p < .001$). Over and above other SH subscale scores in the model, improper sleep scheduling ($\beta = 0.27$, $p < .001$; sr^2 = .27), arousing behaviors near bedtime ($\beta = 0.21$, $p < .001$; sr^2 = .18), and uncomfortable sleeping environment ($\beta = 0.14$, $p = .001$; sr^2 = .13) were significantly associated with concurrent insomnia severity. Table 4 shows the results of the second regression after controlling for well-documented covariates. The covariates accounted for a large portion of the variance in insomnia severity (R^2 = .28). After accounting for these covariates, SH variables explained an additional 5% of the variance in insomnia severity, representing a medium effect for the SH variables. In this model, anxiety severity ($\beta = 0.23$, $p = .002$; sr^2 = .14), depression severity ($\beta = 0.23$, $p < .001$; sr^2 = .14), and improper sleep scheduling ($\beta = 0.20$, $p < .001$; sr^2 = .19) were uniquely and significantly associated with concurrent insomnia severity, over and above other predictors in the model.

For Study 2, multiple linear regression analysis was conducted to predict Time 2 insomnia severity (M = 7.50, SD = 5.39) from Time 1 SH subscale scores after controlling for Time 1 insomnia severity (M = 8.66, SD = 5.36) and well-established covariates of insomnia. This model allowed us to examine whether prior SH behaviors were associated with subsequent insomnia severity. The fact that students, on average, have decreased (as opposed to increased) insomnia over time does not influence interpretation

Table 1
Means (and Standard Deviations) of All Study Variables and Bivariate Correlations of Insomnia Severity Index Scores With Background and Sleep Hygiene Variables in Study 1 and Study 2

	Study 1		Study 2 [b]	
Variable	*M* (*SD*)	*r*	*M* (*SD*)	*r* [c]
Background Variables				
White Race (0 = Non-White; 1 = White)	71%	–.02	76%	–.09
Age (range = 18 to 28)	18.79 (1.37)	.00	18.87 (1.11)	–.01
Female Gender (0 = Male; 1 = Female)	59%	.09*	71%	.04
Morning/Evening Preference	-	-	46.72 (7.56)	–.15
Depression Severity	7.50 (5.33)	.51***	1.37 (1.38)	.32***
Anxiety Severity	7.13 (4.93)	.49***	2.30 (1.71)	.32***
Poor Sleep Hygiene Total Scale Score	42.67 (14.40)	.36***	43.53 (13.82)	.30***
Improper Sleep Scheduling Subscale	9.59 (3.66)	.31***	8.70 (3.82)	.28***
Napped during the day	2.59 (1.98)	.18***	2.42 (1.83)	.00
[a] Woke up at approximately the same time	3.42 (1.61)	.22***	3.03 (1.94)	.21**
[a] Went to bed at approximately the same time	3.57 (1.81)	.24***	3.27 (1.85)	.35***
Use of Sleep Disrupting Products Subscale	5.54 (5.02)	.10*	6.62 (4.69)	.14
Drank caffeinated beverages 5 to 10 hours before bedtime	2.89 (2.49)	.06	2.49 (2.26)	.12
Drank caffeinated beverages within 5 hours of bedtime	2.11 (2.27)	.07	1.79 (1.88)	.13
Drank alcohol within three hours of bedtime.	-	-	1.99 (1.36)	.05
Used cigarette/tobacco within 2 hours of bedtime or at night	0.53 (1.59)	.10*	0.34 (1.25)	.05
Arousing Behaviors Near Bedtime Subscale	11.32 (4.78)	.29***	10.30 (4.86)	.08
Exciting or emotionally upsetting activities near bedtime	2.22 (1.83)	.19***	1.91 (1.72)	.15
Activities demanding high levels of concentration near bedtime	3.37 (1.83)	.17**	2.98 (3.05)	–.05
Exercised within 4 hours of bedtime	1.33 (1.64)	.03	1.33 (1.67)	–.02
Worried, planned, or thought about important matters at bedtime	4.39 (2.05)	.34***	4.08 (2.20)	.12
Usage of Bed for activities Other than Sleep Subscale	11.83 (5.64)	.19***	11.19 (6.08)	.17*
Read in bed	1.49 (1.80)	.04	1.51 (1.87)	–.01
Watched television in bed	2.73 (2.62)	–.01	2.34 (2.68)	.06
Lounged around in bed	3.50 (2.41)	.12**	3.33 (2.40)	.16*
Worried, planned, or thought about important matters in bed	4.11 (2.19)	.34***	4.01 (2.38)	.22**
Uncomfortable Sleep Environment Subscale	4.38 (4.80)	.24***	6.73 (5.72)	.18*
Slept on an uncomfortable mattress	1.04 (2.19)	.13**	1.33 (2.30)	.18*
Slept in a room with an uncomfortable nighttime temperature	1.26 (1.82)	.25***	2.44 (2.38)	.09
Slept in a noisy environment	1.42 (1.82)	.14**	2.06 (2.30)	.07
Slept in a room that was too bright	0.65 (1.43)	.10*	0.91 (1.72)	.16*
Insomnia Severity Index	8.67 (4.88)		8.66 (5.36) at Time 1 7.50 (5.39) at Time 2	

Note. $N = 548$ in Study 1; $N = 157$ in Study 2. [a]These items were reverse-scored; [b]In Study 2, background and sleep hygiene variables were assessed at Time 1 and insomnia symptoms were assessed at Time 2 to match the timeline for regression analyses; [c]These figures reflect correlations between sleep hygiene variables and demographics assessed at Time 1 and insomnia symptoms assessed at Time 2.
* $p < .05$, ** $p < .01$, *** $p < .001$.

of this regression analysis result. That is, a positive coefficient of a predictor indicates that an increase in that predictor is associated with an increase in insomnia severity at Time 2, whereas a negative coefficient for a predictor indicates that an increase in the predictor is associated with a decrease in insomnia

Table 2
Number of Participants for Each Insomnia Category at Time 1 and Time 2 in Study 2

	Time 2		
	Clinical insomnia (*n* = 21, 13%)	Subclinical insomnia (*n* = 43, 27%)	No insomnia (*n* = 93, 59%)
Time 1			
Clinical insomnia (*n* = 22, 14%)	7	10	5
Subclinical insomnia (*n* = 62, 40%)	11	25	26
No insomnia (*n* = 73, 47%)	3	8	62

Note. $N = 157$.

Table 3
Regression Analysis Predicting Insomnia Severity From Sleep Hygiene in Study 1

Predictor	*b*	*SE b*	β	*t*	*p*	sr^2
$R^2 = 0.19$						
Improper sleep scheduling	1.08	0.16	0.27	6.92	<.001	0.27
Use of sleep-disrupting products	–0.50	0.12	–0.02	–0.42	.68	–0.02
Arousing behaviors near bedtime	0.85	0.18	0.21	4.67	<.001	0.18
Bed activities other than sleep	0.18	0.15	0.05	1.22	.22	0.05
Uncomfortable sleep environment	0.57	0.17	0.14	3.45	.001	0.13

Note. $N = 548$.

severity at Time 2, holding all other predictors constant. Significance levels for the SH subscale scores did not differ with and without controlling for the covariates; thus, results of regression analysis controlling for the covariates are presented in Table 5. The covariates explained a large portion of the variance in insomnia severity ($R^2 = .34$). After accounting for these covariates, SH variables explained an additional 5% of the variance in insomnia severity, representing a medium effect size for the SH variables. Time 1 insomnia severity ($\beta = 0.46$, $p < .001$; $sr^2 = .39$) and Time 1 improper sleep scheduling ($\beta = 0.16$, $p = .03$; $sr^2 = .15$) significantly predicted Time 2 insomnia severity, over and above other predictors in the model. This result showed that improper sleep scheduling was the only SH subscale score that was significantly associated with subsequent insomnia severity.

Exploratory Analysis: Comparisons With a Nonclinical Adult Sample

Using the data obtained from our prior study of comparing SH in good and poor sleepers in a national Internet-based sample of adults (Gellis & Lichstein, 2009), we compared the mean SH frequency of the adult sample with that of the current college sample of Study 2. It should be noted that this analysis used nonpublished data and included the total sample from Gellis and Lichstein ($N = 701$) instead of a selected sample of good and poor sleepers for better generalizability. As a comparison sample of college students, we used the Study 2 sample instead of the Study 1 sample, because one SH item (which assesses alcohol use prior to bedtime) was not administered in Study 1. College students ($M = 43.53$, $SD = 13.82$) on average reported a higher level of poor SH behaviors than the nonclinical adults ($M = 33.93$, $SD = 15.80$), representing a medium difference (Cohen's $d = .65$).

Discussion

The present study examined the prevalence of a wide range of SH behaviors and their relationships with insomnia severity both cross-sectionally and prospectively in two independent samples of college students. To our best knowledge, this is the first study that documented prevalence of a full list of SH behaviors (as opposed to an aggregated SH score) and their association with insomnia severity in this population. SH behaviors found to be relatively common (>3 days per week) in our two samples include inconsistent bed and wake-up times, lounging around in the bed, and worry, planning and/or thinking about important matters in the bed. Furthermore, SH was worse among college students in comparison to SH in a nonclinical adult sample from our previous study (Gellis & Lichstein, 2009). Those with higher levels of insomnia severity were more likely to engage in improper sleep scheduling (particularly inconsistent sleep-wake schedules), engage in arousing behaviors near bedtime, and report uncomfortable sleeping environments. Five SH factors together explained 19% of the variance in insomnia severity when measured cross-sectionally, and an additional 5% of the variance in insomnia severity after controlling for other risk factors when measured cross-sectionally and prospectively. Overall, these findings suggest a large effect of SH factors in the prediction of cross-sectional insomnia severity, and a medium effect of SH factors over and above other risk factors in the prediction of cross-sectional and short-term prospective insomnia severity in college students. In terms of specific SH factors, improper sleep scheduling was significantly associated with concurrent insomnia severity, and it significantly and positively predicted insomnia severity 2 month later, even after controlling for all other SH behaviors and well-established risk factors for insomnia. Together, these findings suggest a potential unique role of improper sleep scheduling in the development and maintenance of insomnia among college students.

Overall, poor SH behaviors appear to be more frequent in college students than a nonclinical adult sample, with a medium difference in total mean SH scores. This increase in poor SH behaviors among college students may be due to numerous reasons

Table 4
Regression Analysis Predicting Insomnia Severity From Sleep Hygiene, After Controlling for Covariates in Study 1

Predictor	*b*	*SE b*	β	*t*	*p*	sr^2
Step 1: Covariates (R^2 = 0.28)						
Female gender	0.30	0.36	0.03	0.81	.42	0.03
Anxiety severity	0.25	0.06	0.25	4.45	<.001	0.16
Depression severity	0.32	0.06	0.31	5.36	<.001	0.20
Step 2: Sleep Hygiene (ΔR^2 = 0.05)						
Female gender	0.18	0.36	0.02	0.51	.61	0.02
Anxiety severity	0.23	0.06	0.23	4.00	<.001	0.14
Depression severity	0.24	0.06	0.23	4.10	<.001	0.14
Improper sleep scheduling	0.26	0.05	0.20	5.37	<.001	0.19
Use of sleep-disrupting products	−0.03	0.04	−0.03	−0.72	.47	−0.03
Arousing behaviors near bedtime	0.07	0.04	0.07	1.64	.10	0.06
Bed activities other than sleep	0.03	0.03	0.03	0.73	.47	0.03
Uncomfortable sleep environment	0.06	0.04	0.06	1.54	.12	0.05

Note. N = 548.

(e.g., dorm living, social priorities, newfound freedoms, lack of knowledge). These unique life situations associated with SH behaviors may suggest that the results pertaining to the significance of SH are only relevant to college students and cannot be generalized to the adult population. Relatedly, in our longitudinal sample (Study 2), a small decrease in insomnia severity on average was found over a 2-month period, albeit 60% of students remained in the same insomnia category. This decrease in insomnia symptoms may be related to our assessment points. Time 1 assessment occurred around the beginning of a new semester (September) when students are adjusting a new living arrangement and class schedule, which may increase insomnia symptoms. By the time of Time 2 assessment in the end of semester (November), students may have adjusted to the new environment, which may decrease insomnia symptoms. Future prospective studies of college insomnia as a function of academic schedule may elucidate this potential natural fluctuation in insomnia among college students.

Consistent sleep schedules are important in order to align one's preferred sleep-wake schedule to their endogenous circadian rhythm, allowing the individual to pursue sleep at a time when sleep is maximally promoted. Our results show that college students

Table 5
Regression Analysis Predicting Insomnia Severity at Time 2 From Sleep Hygiene at Time 1, After Controlling for Covariates and Insomnia Severity at Time 1 in Study 2

Time 1 predictor	*b*	*SE b*	β	*t*	*p*	sr^2
Step 1: Time 1 Insomnia Severity and Covariates (R^2 = 0.34)						
Insomnia severity	0.50	0.07	0.49	6.65	<.001	0.44
Female gender	0.34	0.80	0.03	0.43	.67	0.03
Anxiety severity	0.22	0.26	0.07	0.86	.39	0.06
Depression severity	0.35	0.33	0.09	1.06	.29	0.07
Morning/evening preference	−0.07	0.05	−0.10	−1.56	.12	−0.10
Step 2: Sleep Hygiene (ΔR^2 = 0.05)						
Insomnia severity	0.46	0.08	0.46	6.04	<.001	0.39
Female gender	0.22	0.80	0.02	0.27	.79	0.02
Anxiety severity	0.38	0.27	0.12	1.42	.16	0.09
Depression severity	0.24	0.32	0.06	0.74	.46	0.05
Morning/evening preference	−0.06	0.05	−0.08	−1.15	.25	−0.08
Improper sleep scheduling	0.22	0.10	0.16	2.23	.03	0.15
Use of sleep-disrupting products	0.09	0.08	0.08	1.20	.23	0.08
Arousing behaviors near bedtime	−0.16	0.08	−0.14	−1.92	.06	−0.13
Bed activities other than sleep	0.02	0.07	0.02	0.29	.77	0.02
Uncomfortable sleep environment	0.07	0.07	0.08	1.08	.28	0.07

Note. N = 157.

frequently have inconsistent sleep schedules, which is in line with previous research (Lund et al., 2010). Furthermore, our study expands the literature to show that improper sleep schedules are associated with insomnia, even after controlling for well-established risk factors for insomnia severity, and that inconsistent sleep schedules are a significant predictor of subsequent insomnia severity over a short time period. There are many potential reasons why college students have improper sleep schedules, including late-night parties, late-night studying, and class schedules that vary during the week. It should be noted that the improper sleep-wake schedules are associated with insomnia after controlling for other SH behaviors related to late-night wakefulness (e.g., studying, exercising, worrying, and using sleep-disrupting products). Improper sleep schedules also predicted insomnia after controlling for morning/evening preference, which may cause sleep difficulty because of disparities in one's preferred versus necessary sleep time (e.g., an individual with an evening preference may have difficulties in falling asleep early in the night), and also may further cause irregular wake or bed times due to fluctuating daytime schedules (e.g., an individual with an evening preference may wake up later on days without morning classes). Thus, the association between improper sleep schedules and insomnia severity does not seem to be due to late-night wakefulness or individual characteristics that may cause irregular wake and bedtimes.

Results of means and cross-sectional bivariate correlations suggest that arousing behaviors near bedtime and using the bed for activities other than sleep were highly common in college students and were associated with higher insomnia severity. This finding is consistent with the current understanding of insomnia as a disorder of hyperarousal (Bonnet & Arand, 2010). Bedtime-arousing behaviors, however, were not associated with insomnia severity after controlling for other risk factors such as anxiety and depression, trait characteristics that may also cause nighttime arousal. Bedtime-arousing behaviors also did not predict subsequent insomnia severity over a short time period, both with and without controlling for other risk factors. This finding does not support the notion that repeated engagement in arousing or sleep-incompatible activities in the bedroom causes hyperarousal conditioned to occur in the bedroom environment, which in turn perpetuates insomnia (Bootzin, 1972). Instead, arousing behaviors near bedtime and using the bed for activities other than sleep and insomnia may be related to each other, because they are being driven by the same underlying trait (such as anxiety and depression) or other variables (such as situational stressors) that lead to arousal. Thus, our results suggest that arousing behaviors near bedtime may not be a major factor influencing insomnia in college students.

Our results suggest that associations of uncomfortable sleep environments with insomnia may be complex. Sleep-disturbing environmental conditions showed small correlations with insomnia severity. However, environmental conditions were unrelated to insomnia severity after controlling for covariates; also, they did not predict insomnia severity 2 months later, controlling for covariates. Thus, the correlations between sleep-disturbing environmental conditions and insomnia may be better explained by negative affect and/or other personal factors. Also, people with greater insomnia severity may be likely to notice more uncomfortable environmental conditions, because they are awake at night, as opposed to being awake by the poor environmental conditions.

All substance-related sleep hygiene variables were unrelated to insomnia severity concurrently and prospectively in both samples, except for a small association with cigarette smoking in Study 1. These null results are consistent with prior findings of either small or no correlation between alcohol use and insomnia severity among college students (Kenney et al., 2012; Taylor et al., 2013), though it should be noted that alcohol use was only measured in Study 2. Although alcohol is shown to increase awakenings during the night and disturb sleep architecture, these negative effects may not be significant enough to warrant the complaint of insomnia severity and may be counteracted by the temporary promotion of initial sleep onset after alcohol use (Roehrs, & Roth, 2001). Caffeine use was also unrelated to insomnia severity, which is consistent with previous studies in community-based adults (Gellis & Lichstein, 2009; Jefferson et al., 2005). It should be noted that our sleep hygiene measure assessed a broad range of caffeinated beverages (including coffee, tea, or soft drinks), and it is unclear whether only specific caffeine products (e.g., soft drinks only) are related to insomnia severity. Overall, despite well-established prevalence of substance and caffeinated beverage use among college students (Johnston, O'Malley, Bachman, & Schulenberg, 2012), our findings suggest that usage of sleep-disturbing products may not affect insomnia in college students.

These findings have clinical implications for treating and preventing insomnia in college students. Our findings suggest that having improper sleep scheduling and engaging in activities other than sleep in the bed are common among college students, whereas using sleep-disturbing products and sleep-disturbing sleep environments are less common. Of particular interest, improper sleep schedules were associated with an increase in insomnia severity over

time. Interestingly, stimulus control therapy, one of the evidence-based treatments for insomnia (Morin et al., 2006), focuses on instructions to use the bed only for sleep and establish consistent sleep-wake schedules, which pertains to the most frequently reported behaviors in this population. These behaviors have only recently been incorporated under the classification of sleep hygiene behaviors. Traditional sleep hygiene education programs, not shown to be effective for insomnia (Morgenthaler et al., 2006), tend to focus on sleep-related environmental factors and eating and substance use behaviors, which we found are either very infrequent or not associated with insomnia severity. Thus, education on the importance of good SH, particularly highlighting the role of inconsistent sleep schedules in impacting sleep, may be helpful to mitigate insomnia among college students. In fact, a recent study found large effects of a brief 15-minute intervention on the importance of good SH, which included stimulus-control-related elements, on decreases in insomnia severity at the 1-month follow-up among college students (Gellis, Arigo, & Eliot, 2013). It should be noted that, while it is possible college students would benefit from interventions to improve SH, students may not be motivated to improve poor SH behaviors due to prioritizing social or school-related activities over better sleep. Further studies should evaluate the effect of specific education and treatment programs, focusing on improving sleep schedules and the use of the bed for sleep, in this population.

These findings must be interpreted within the confines of several limitations. First, data were collected from two convenient samples of mostly younger, White students at a private university in the northeast United States. Also, in Study 2, students were eligible for participation only if they had taken alcohol in the last 30 days; thus, the findings from Study 2 may not be applicable to abstainers. However, our prevalence rates of insomnia were remarkably similar to prior studies and mean levels of SH behaviors and correlations of the SH behaviors with insomnia severity were similar between our two samples, suggesting that this sampling bias may not be substantial. Nonetheless, these sample characteristics should be considered when interpreting our findings, and replication with more representative samples is necessary for generalization of our findings. Second, participants who were excluded because of missing data or who withdrew from the study at follow-up tended to have higher insomnia severity, which may bias the prediction of those with a higher range of insomnia severity in our analyses. Third, both the SH and insomnia severity measures were retrospective in nature, which is vulnerable to biased or inaccurate responding. Future research should assess SH behaviors and insomnia using daily measurements. Finally, this study is correlational in nature and thus we cannot draw conclusions about any cause-and-effect relationships among the study variables. We found that Time 1 improper sleep schedules predicted Time 2 insomnia severity after controlling for Time 1 insomnia severity and other risk factors; however, other variables that were not controlled for in this study may have explained the relationship.

Despite these limitations, the current study is the first study that illustrates the short-term predictive power of sleep hygiene for college students' insomnia, over and above the influences of well-established insomnia risk factors. Future studies with longer follow-up assessments are necessary to characterize long-term effects of sleep hygiene on college students' insomnia severity.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest.

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Received: January 31, 2014
Accepted: May 21, 2014
Available online 2 June 2014